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IRRIGATION.[1]

SCIENCE has been defined as the medium through which the knowledge of the few can be rendered available to the many; and among the first to avail himself of this knowledge is the engineer. He has created a young science, the offspring, as it were, of the older sciences, for without them engineering could have no existence.

The astronomer, gazing through long ages at the heavens and laying down the courses of the stars, has taught the engineer where to find his place on the earth's surface.

The geologist has taught him where he may find the stones and the minerals which he requires, where he may count on firm rock beneath the soil to build on, where he may be certain he will find none.

The chemist has taught him of the subtle gases and fluids which fill all space, and has shown him how they may be transformed and transfused for his purposes.

The botanist has taught him the properties of all trees and plants, 'from the cedar tree that is in Lebanon even unto the hyssop that springeth out of the wall.'

And all this knowledge would be as nothing to the engineer had he not reaped the fruits of that most severe of all pure and noble sciences—the science of numbers and dimensions, of lines and curves and spaces, of surfaces and solids—the science of mathematics.

Were I to attempt in the course of a single address to touch on all the many

[1] Address of the president to the Engineering Section of the British Association for the Advancement of Science, South Africa, 1905.

branches of engineering, I could do no more than repeat a number of platitudes, which you know at least as well as I do. You would probably have fallen asleep before I was half finished, and it would be the best thing you could do. I think, then, that it will be better to select one branch, a branch on which comparatively little has been written, which has, I understand, a special interest for South Africa, and which has occupied the best years of my life in India, southern Europe, central Asia and Egypt—I mean the science of irrigation. My subject is water—living, life-giving water. It can surely never be a dry subject; but we all know that with the best text to preach on the preacher may be as dry as dust.

IRRIGATION: WHAT IT MEANS.

Irrigation may be defined as the artificial application of water to land for the purposes of agriculture. It is, then, precisely the opposite of drainage, which is the artificial removal of water from lands which have become saturated, to the detriment of agriculture. A drain, like a river, goes on increasing as affluents join it. An irrigation channel goes on diminishing as water is drawn off it. Later on I shall show you how good irrigation should always be accompanied by drainage.

In lands where there is abundant rainfall, and where it falls at the right season of the year for the crop which it is intended to raise, there is evidently no need of irrigation. But it often happens that the soil and the climate are adapted for the cultivation of a more valuable crop than that which is actually raised, because the rain does not fall just when it is wanted, and there we must take to artificial measures.

In other lands there is so little rain that it is practically valueless for agriculture, and there are but two alternatives—irrigation or desert. It is in countries like these that irrigation has its highest triumph; nor are such lands always to be pitied or despised. The rainfall in Cairo is on an average 1.4 inch per annum, yet lands purely agricultural are sold in the neighborhood as high as £150 an acre.

This denotes a fertility perhaps unequaled in the case of any cultivation depending on rain alone, and this in spite of the fact that the Egyptian cultivator is in many respects very backward. The explanation is not far to seek. All rivers in flood carry along much more than water. Some carry alluvial matter. Some carry fine sand. Generally the deposit is a mixture of the two. I have never heard of any river that approached the Nile in the fertilizing nature of the matter borne on its annual floods; with the result that the plains of Egypt have gone on through all ages, with the very minimum of help from foreign manures, yielding magnificent crops and never losing their fertility. Other rivers bring down little but barren sand, and any means of keeping it off the fields should be employed.

PRIMITIVE MEANS OF IRRIGATION.

The earliest and simplest form of irrigation is effected by raising water from a lake, river or well, and pouring it over the land. The water may be raised by any mechanical power, from the brawny arms of the peasant to the newest pattern of pump. The earliest Egyptian sculptures show water being raised by a bucket attached to one end of a long pole, turning on an axis with a heavy counterpoise at the other end. In Egypt this is termed a *shadoof*, and to this day, all along the Nile banks, from morning to night, brown-skinned peasants may be seen watering their fields in precisely this way. Tier above tier they ply their work so as to raise water fifteen or sixteen feet on to their land. By this simple contrivance it

is not possible to keep more than about four acres watered by one *shadoof,* so you may imagine what an army is required to irrigate a large surface. Another method, largely used by the natives of northern India, is the shallow bucket suspended between two strings, held by men who thus bale up the water. A step higher is the water-wheel, with buckets or pots on an endless chain around it, worked by one or a pair of bullocks. This is a very ordinary method of raising the water throughout the East, where the water-wheel is of the rudest wooden construction and the pots are of rough earthenware. Yet another method of water-raising is very common in India from wells where the spring level may be as deep as one hundred feet or more. A large leathern bag is let down the well by a rope passing over a pulley and raised by a pair of bullocks, which haul the bag up as they run down a slope the depth of the well. An industrious farmer with a good well and three pairs of good bullocks can keep as much as twelve acres irrigated in northern India, although the average is much less there. The average cost of a masonry well in India varies from £20 to £40, according to the depth required. But it is obvious that in many places the geological features of the country are such that well-sinking is impracticable. The most favorable conditions are found in the broad alluvial plains of a deltaic river, the subsoil of which may be counted on as containing a constant supply of water.

PUMPS AND WINDMILLS.

All these are the primitive water-raising contrivances of the East. Egypt has of late been more in touch with Western civilization, and since its cotton and sugar-cane crops yield from £6 to £8, or even £10 per acre, the well-to-do farmer can easily afford a centrifugal pump worked by steam power. Of these there are now many hundreds fixed or portable working on the Nile banks in Egypt. Where wind can be counted on the windmill is a very useful and cheap means of raising water. But everything depends on the force and the reliability of the wind. In the dry western states of America wind power is largely used for pumping. It is found that this power is of little use if its velocity is not at least six miles per hour. (The mean force of the wind throughout the whole United States is eight miles per hour.) Every windmill, moreover, should discharge its water into a tank. It is evident that irrigation can not go on without cessation day and night, and it may be that the mill is pumping its best just when irrigation is least wanted. The water should, therefore, be stored till required. In America it is found that pumping by wind power is about two-thirds of the cost of steam power. With a reservoir five to fifteen acres may be kept irrigated by a windmill. Without a reservoir three acres is as much as should be counted on. Windmills attached to wells from 30 to 150 feet deep cost from £30 to £70.

ARTESIAN WELLS.

Up to now the artesian well can not be counted on as of great value for irrigation. In the state of California there are said to be 8,097 artesian wells, of a mean depth of 210 feet, discharge .12 cubic feet per second, and original cost on an average £50. Thirteen acres per well is a large outturn.

In Algeria the French have bored more than 800 artesian wells, with a mean depth of 142 feet, and they are said to irrigate 50,000 acres. But this is scattered over a large area. Otherwise, the gathering ground would probably yield a much smaller supply to each well than it now has. In Queensland artesian wells are largely used for the water supply of cattle stations, but not for irrigation.

WELL IRRIGATION.

It is evident that where water has to be raised on to the field there is an outlay of human or mechanical power which may be saved if it can be brought to flow over the fields by gravitation. But there is one practical advantage in irrigating with the water raised from one's own well or from a river. It is in the farmer's own hands. He can work his pump and flood his lands when he thinks best. He is independent of his neighbors, and can have no disputes with them as to when he may be able to get water and when it may be denied to him. In Eastern countries, where corruption is rife among the lower subordinates of government, the farmer who sticks to his well knows that he will not require to bribe any one; and so it is that in India about thirteen millions of acres, or 30 per cent. of the whole annual irrigation, is effected by wells. Government may see fit to make advances to enable the farmer to find his water and to purchase the machinery for raising it; or joint-stock companies may be formed with the same object. Beyond this all is in the hands of the landowner himself.

CANAL IRRIGATION.

Irrigation on a large scale is best effected by diverting water from a river or lake into an artificial channel, and thence on to the fields. If the water surface of a river has a slope of two feet per mile, and a canal be drawn from it with a surface slope of one foot per mile, it is evident that at the end of a mile the water in the canal will be one foot higher than that in the river; and if the water in the river is ten feet below the plain, at the end of ten miles the water in the canal will be flush with the plain, and henceforth irrigation can be effected by simple gravitation.

When there is no question of fertilizing deposit, and only pure water is to be had, the most favorable condition of irrigation is where the canal or the river has its source of supply in a great lake. For, be the rainfall ever so heavy, the water surface in the lake will not rise very much, nor will it greatly sink at the end of a long drought. Where there is no moderating lake, a river fed from a glacier has a precious source of supply. The hotter the weather, the more rapidly will the ice melt, and this is just when irrigation is most wanted.

Elsewhere, if crops are to be raised and the rain can not be counted on, nor well irrigation be practised, water storage becomes necessary, and it is with the help of water storage that in most countries irrigation is carried on.

WATER STORAGE.

To one who has not given the subject attention surprise is often expressed at the large volume of water that has to be stored to water an acre of land. In the case of rice irrigation in India, it is found that the storage of a million cubic feet does not suffice for more than from six to eight acres. For the irrigation of wheat about one third this quantity is enough. It would never pay to excavate on a level plain a hollow large enough to hold a million cubic feet of water. It is invariably done by throwing a dam across the bed of a river or a valley and ponding up the water behind it. Many points have here to be considered: The length of dam necessary, its height, the material of which it is to be constructed, the area and the value of the land that must be submerged, the area of the land that may be watered. The limits of the height of a dam are from about 150 to 15 feet. If the slope of the valley is great it may be that the volume which can be ponded up with a dam of even 150 feet is inconsiderable, and the cost may be prohibitory. On the other hand, if the country is very flat, it may be that a dam of only 20 feet high may require to be of quite an inor-

dinate length, and compensation for the area of land to be submerged may become a very large item in the estimate. I have known of districts so flat that in order to irrigate an acre more than an acre must be drowned. This looks ridiculous, but is not really so, for the yield of an irrigated acre may be eight or ten times that of an unirrigated one; and after the storage reservoir has been emptied it is often possible to raise a good crop on the saturated bed.

The advantage of a deep reservoir is, however, very great, for the evaporation is in proportion to the area of the surface, and if two reservoirs contain the same volume of water, and the depth of one is double that of the other, the loss by evaporation from the shallow one will be double that of the deep one. In India, from time immemorial, it has been the practise to store water for irrigation, and there are many thousands of reservoirs, from the great artificial lakes holding as much as 5,000 or 6,000 millions of cubic feet, down to the humble village tank holding not a million. There are few of which the dam exceeds 80 feet in height, and such are nearly always built of masonry or concrete. For these it is absolutely necessary to have sound rock foundations. If the dam is to be of earth, the quality of the soil must be carefully seen to, and there should be a central core of puddle resting on rock and rising to the maximum height of water surface. If the dam is of masonry, there may perhaps be no harm done should the water spill over the top. If it is of earth, this must never happen, and a waste weir must be provided, if possible cut out of rock or built of the best masonry, and large enough to discharge the greatest possible flood. More accidents occur to reservoirs through the want of sufficient waste weirs or their faulty construction than from any other cause.

As important as the waste weir are the outlet sluices through which the water is conveyed for the irrigation of the fields. If possible they should be arranged to serve at the same time as scouring sluices to carry off the deposit that accumulates at the bottom of the reservoir. For, unless provided with very powerful scouring sluices, sooner or later the bed of the reservoir will become silted up, and the space available for water storage will keep diminishing. As this happens in India, it is usual to go on raising the embankment (for it does not pay to dig out the deposit), and so the life of a reservoir may be prolonged for many years. Ultimately it is abandoned, as it is cheaper to make a new reservoir altogether than to dig out the old one.

ITALIAN IRRIGATION.

For the study of high-class irrigation there is probably no school so good as is to be found in the plains of Piedmont and Lombardy. Every variety of condition is to be found here. The engineering works are of a very high class, and from long generations of experience the farmer knows how best to use his water.

The great river Po has its rise in the foothills to the west of Piedmont. It is not fed from glaciers, but by rain and snow. It carries with it a considerable fertilizing matter. Its temperature is higher than that of glacial water—a point to which much importance is attached for the very valuable meadow irrigation of winter. From the left bank of the Po, a few miles below Turin, the great Cavour Canal takes its rise, cutting right across the whole drainage of the country. It has a full-supply discharge of 3,800 cubic feet per second; but it is only from October to May that it carries anything like this volume. In summer the discharge does not exceed 2,200 cubic feet per second, which would greatly cripple the value of the work were

it not that the glaciers of the Alps are melting then, and the great torrents of the Dora Baltea and Sesia can be counted on for a volume exceeding 6,000 cubic feet per second.

Lombardy is in no respect worse off than Piedmont for the means of irrigation; and its canals have the advantage of being drawn from the lakes Maggiore and Como, exercising a moderating influence on the Ticino and Adda Rivers, which is sadly wanted on the Dora Baltea. The Naviglio Grande of Lombardy is drawn from the left bank of the Ticino, and is used largely for navigation, as well as irrigation. It discharges between 3,000 and 4,000 cubic feet per second, and nowhere is irrigation probably carried on with less expense. From between Lake Maggiore and the head of the Naviglio Grande a great new canal, the Villoresi, has been constructed during the last few years with head sluices capable of admitting 6,700 cubic feet per second, of which, however, 4,200 cubic feet have to be passed on to the Naviglio Grande. Like the Cavour Canal, the Villoresi crosses all the drainage coming down from the foothills to the north. This must have entailed the construction of very costly works.

IRRIGATION IN NORTHERN INDIA.

It is in India that irrigation on the largest scale is to be found. The great plains of northern India are peculiarly well adapted for irrigation, which is a matter of life and death to a teeming population all too well accustomed to a failure of the rain supply.

The Ganges, the Jumna and the great rivers of the Punjab have all been largely utilized for feeding irrigation canals. The greatest of these, derived from the river Chenab, and discharging from 10,500 to 3,000 cubic feet per second, was begun in 1889, with the view of carrying water into a tract entirely desert and unpopulated. It was opened on a small scale in 1892, was then enlarged, and ten years after it irrigated in one year 1,829,000 acres, supporting a population of 800,000 inhabitants, colonists from more congested parts of India.

The Ganges Canal, opened in 1854, at a time when there was not a mile of railway, and hardly a steam engine within a thousand miles, has a length of about 9,900 miles, including distributing channels. It was supplemented in 1878 by a lower canal, drawn from the same river 130 miles further down, and these two canals now irrigate between them 1,700,000 acres annually. On all these canals are engineering works of a very high class. The original Ganges Canal, with a width of bed of 200 feet, a depth of ten feet, and a maximum discharge of 10,000 cubic feet per second, had to cross four great torrents before it could attain to the watershed of the country, after which it could begin to irrigate. Two of these torrents are passed over the canal by broad super-passages. Over one of them the canal is carried in a majestic aqueduct of fifteen arches, each of fifty feet span; and the fourth torrent, the most difficult of all to deal with, crosses the canal at the same level, a row of forty-seven floodgates, each ten feet wide, allowing the torrent to pass through and out of the canal.

Elsewhere there are rivers in India, rising in districts subject to certain heavy periodical rainfall, and carrying their waters on to distant plains of very uncertain rainfall. At a small expense channels can sometimes be constructed drawing off from the flooded river water sufficient thoroughly to saturate the soil, and render it fit to be ploughed up and sown with wheat or barley, which do not require frequent watering. The canal soon dries up, and the sown crop must take its chance; but a timely shower of rain may come in to help it, or well irrigation

may mature the crop. These, which are known in India as inundation canals, are of high value.

SOUTHERN INDIA.

In southern India there are three great rivers, drawing their supply from the line of hills called the Ghats, running parallel to and near the western coast, and after a long course discharging into the Bay of Bengal on the east coast. Against the Ghats beats the whole fury of the tropical southwest monsoon, and these rivers for a few months are in high flood. As they approach the sea they spread out in the usual deltaic form. Dams have been built across the apex of these deltas, from which canals have been drawn, and the flood waters are easily diverted over the fields, raising a rice crop of untold value in a land where drought and famine are too common. But for the other months of the year these rivers contain very little water, and there is now a proposition for supplementing them with very large reservoirs.

A very bold and successful piece of irrigation engineering was carried out a few years ago in south India, which deserves notice. A river named the Periyar took its rise in the Ghats, and descended to the sea on the west coast, where there was no means of utilizing the water, and a good deal of money had periodically to be spent in controlling its furious floods. A dam has now been built across its course, and a tunnel has been made through the mountains, enabling the reservoir to be discharged into a system of canals to the east, where there is a vast plain much in need of water.

In the native state of Mysore, in southern India, there are on the register about 40,000 irrigation reservoirs (or tanks, as they are called), or about three to every four square miles, and the nature of the country is such that hundreds may be found in the basin of one river—small tanks in the upper branches and larger ones in the lower, as the valley widens out, and these require constant watchful attention. From time to time tropical rainstorms sweep over the country. If then even a small tank has been neglected, and rats and porcupines have been allowed to burrow in the dam, the flood may burst through it, and sweep on and over the dam of the next village, lower down. One dam may then burst after another, like a pack of cards, and terrible loss occurs.

In this state of Mysore a very remarkable irrigation reservoir is now under construction at a place called Mari Kanave. Nature seems here to have formed an ideal site for a reservoir, so that it is almost irresistible for the engineer to do his part, even although irrigation is not so badly wanted here as elsewhere. The comparatively narrow neck of a valley containing 2,075 square miles is being closed by a masonry dam 142 feet high. The reservoir thus formed will contain 30,000 million cubic feet of water, but it is not considered that it will fill more than once in thirty years. Nor is there irrigable land requiring so great a volume of water. Much less would be sufficient, so such a high dam is not needed; but the construction of a waste weir to prevent the submergence of a lower dam would require such heavy excavation through one of the limiting hills that it is cheaper to raise the dam and utilize a natural hollow in the hillside for a waste weir.

IRRIGATION IN EGYPT.

No lecture on irrigation would be complete without describing what has been done in Egypt. You are generally familiar with the shape of that famous little country. Egypt proper extends northwards from a point in the Nile about 780 miles above Cairo—a long valley, never eight miles wide, sometimes not a half a mile.

East and west of this lies a country broken into hills and valleys, wild crags, level stretches, but everywhere absolutely sterile, dry sand and rock, at such a level that the Nile flood has never reached it to cover its nakedness with fertile deposit. A few miles north of Cairo the river bifurcates, and its two branches flow each for about 130 miles to the sea. As you are probably aware, with rivers in a deltaic state the tendency is for the slope of the country to be away from the river, and not towards it. In the Nile Valley the river banks are higher than the more distant lands. From an early period embankments were formed along each side of the river, high enough not to be topped by the highest flood. At right angles to these river embankments others were constructed, dividing the whole valley into a series of oblongs, surrounded on three sides by embankments, on the fourth by the desert heights. These oblong areas vary from about 50,000 to 3,000 acres. I have said the slope of the valley is away from the river. It is easy, then, when the Nile is low, to cut short deep canals in the river banks, which fill as the river rises and carry the precious mud-charged water into these great flats. There the water remains for a month or more, some three or four feet deep, depositing its mud, and then at the end of the flood it may either be run off direct into the receding river, or cuts may be made in the cross embankments and the water passed off one flat after another, and finally rejoin the river. This takes place in November, when the river is rapidly falling. Whenever the flats are firm enough to allow a man to walk over them with a pair of bullocks, the mud is roughly turned over with a wooden plough, or even the branch of a tree, and wheat or barley is immediately sown. So soaked is the soil after the flood that the seed germinates, sprouts and ripens in April without a drop of rain or any more irrigation, except what, perhaps, the owner may give from a shallow well dug in the field. In this manner was Egypt irrigated up to about a century ago. The high river banks which the flood could not cover were irrigated directly from the river, the water being raised as I have already described.

THE BARRAGE.

With the last century, however, appeared a very striking figure in Egyptian history, Muhammed Ali Pasha, who came from Turkey a plain captain of infantry, and before many years had made himself master of the country, yielding only a very nominal respect to his suzerain lord, the Sultan, at Constantinople.

Muhammed Ali soon recognized that with this flood system of irrigation only one cereal crop was raised in the year, while with such a climate and such a soil, with a teeming population and with the markets of Europe so near, something far more valuable might be raised. Cotton and sugar-cane would fetch far higher prices; but they could only be grown at a season when the Nile is low, and they must be watered at all seasons. The water-surface at low Nile is about twenty-five feet below the flood-surface, or more than twenty feet below the level of the country A canal, then, running twelve feet deep in the flood would have its bed thirteen feet above the low-water surface. Muhammed Ali ordered the canals in lower Egypt to be deepened; but this was an enormous labor, and as they were badly laid out and graded they became full of mud during the flood and required to be dug out afresh. Muhammed Ali was then advised to raise the water-surface by erecting a dam (or, as the French called it, a *barrage*) across the apex of the delta, twelve miles north of Cairo, and the result was a very costly and imposing work, which it took long years and untold wealth to construct, and which

was no sooner finished than it was condemned as useless.

EGYPTIAN IRRIGATION SINCE THE ENGLISH OCCUPATION.

With the English occupation in 1883 came some English engineers from India, who, supported by the strong arm of Lord Cromer, soon changed the situation. The first object of their attention was the *barrage* at the head of the delta, which was made thoroughly sound in six years and capable of holding up fifteen feet of water. Three great canals were taken from above it, from which a network of branches are taken, irrigating the province to the left of the western, or Rosetta branch of the river, the two provinces between the branches, and the two to the right of the eastern, or Damietta branch.

In upper Egypt, with one very important exception (the Ibrahimieh Canal, which is a perennial one), the early flood system of irrigation, yielding one crop a year, prevailed until very recently, but it was immensely improved after the British occupation by the addition of a great number of masonry head sluices, aqueducts, escape weirs, etc., on which some £800,000 was spent. With the completion of these works, and of a complete system of drainage, to be alluded to further on, it may be considered that the irrigation system of Egypt was put on a very satisfactory basis. There was not much more left to do, unless the volume of water at disposal could be increased.

Probably no large river in the world is so regular as the Nile in its periods of low supply and of flood. It rises steadily in June, July and August. Then it begins to go down, at first rapidly, then slowly, till the following June. It is never a month before its time, never a month behind. It is subject to no exceptional floods from June to June. Where it enters Egypt the difference between maximum and minimum Nile is about twenty-five feet. If it rises three and one half feet higher the country is in danger of serious flooding. If its rise is six feet short of the average there existed in former days a great risk that the floods would never cover the great flats of upper Egypt, and thus the ground would remain as hard as stone, and sowing in November would be impossible. Fortunately the good work of the last twenty years very much diminishes this danger.

THE ASSUAN DAM AND RESERVOIR.

In average years the volume of water flowing past Cairo in September is from thirty-five to forty times the volume in June. Far the greater part of this flood flows out to the sea useless. How to catch and store this supply for use the following May and June was a problem early pressed on the English engineers in Egypt.

During the time of the highest flood the Nile carries along with it an immense amount of alluvial matter, and when it was first proposed to store the flood-water the danger seemed to be that the reservoir would in a few years be filled with deposit, as those I have described in India. Fortunately it was found that after November the water was fairly clear, and that if a commencement were made even as late as that there would still be water enough capable of being stored to do enormous benefit to the irrigation.

A site for a great dam was discovered at Assuan, 600 miles south of Cairo, where a dyke of granite rock crosses the valley of the river, occasioning what is known as the First Cataract. On this ridge of granite a stupendous work has now been created. A great wall of granite 6,400 feet long has been thrown across the valley, 23 feet thick at the crest, 82 feet at the base. Its height above the rock-bed of the river is 130 feet. This great wall or dam holds up a depth

of 66 feet of water, which forms a lake of more than 100 miles in length up the Nile Valley, containing 38,000 million cubic feet of water.

The dam is pierced with 180 sluices, or openings, through which the whole Nile flood, about 360,000 cubic feet per second, is discharged. A flight of four locks, each 260 by 30 feet, allows of free navigation past the dam. The foundation-stone of this great work was laid in February 1899, and it was completed in less than four years. At the same time a very important dam of the pattern of the barrage north of Cairo was built across the Nile at Assiut, just below the head of the Ibrahimieh Canal, not with the object of storing water, but to enable a requisite supply at all times to be sent down that canal.

The chief use of the great Assuan reservoir is to enable perennial irrigation, such as exists in lower Egypt, to be substituted in upper Egypt for the basin system of watering the land only through the Nile flood; that is, to enable two crops to be grown instead of one every year, and to enable cotton and sugar-cane to take the place of wheat and barley. But a great deal more had to be done in order to obtain the full beneficial result of the work. About 450,000 acres of basin irrigation are now being adapted for perennial irrigation. Many new canals have had to be dug, others to be deepened. Many new masonry works have had to be built. It is probable the works will be finished in 1908. There will then have been spent on the great dam at Assuan, the minor one at Assiut, and the new canals of distribution in upper Egypt about six and a half millions sterling. For this sum the increase of land rental will be about £2,637,000, and its sale value will be increased by about £26,570,000.

DRAINAGE.

In the great irrigation systems which I have been describing for a long time little or no attention was paid to drainage. It was taken for granted that the water would be absorbed, or evaporated, and get away somehow without doing any harm. This may hold good for high-lying lands, but alongside of these are low-lying lands, into which the irrigation water from above will percolate and produce waterlogging and marsh. Along with the irrigation channel should be constructed the drainage channel, and Sir W. Willcocks, than whom there is no better authority on this subject, recommends that the capacity of the drain should be one third that of the canal. The two should be kept carefully apart—the canal following the ridges, the drain following the hollows of the country, and one in no case obstructing the other. This subject of drainage early occupied the attention of the English engineers in Egypt. In the last twenty years many hundred miles of drains have been excavated, some as large as 50 feet width of bed and 10 feet deep.

IRRIGATION IN AMERICA.

If it is to Italy that we should look for highly finished irrigation works and careful water distribution, and to India and Egypt for widespreading tracts of watered land, it is to America that we naturally look for rapid progress and bold engineering. In the western states of America there is a rainfall of less than 20 inches per annum, the consequence of which is a very rapid development of irrigation works. In 1889 the irrigation of these western states amounted to 3,564,416 acres. In 1900 it amounted to 7,539,545 acres. Now it is at least 10,000,000 acres. The land in these states sells from 10s. to £1 per acre if unirrigated. With irrigation the same land fetches £8 10s. per acre. The works are often rude and of a temporary nature, the extensive use of timber striking a foreigner from the old world. Some of the

American canals are on a large scale. The Idaho Company's canal discharges 2,585 cubic feet, the Turlook Canal in California 1,500 cubic feet, and the North Colorado Canal 2,400 cubic feet per second. These canals have all been constructed by corporations or societies, in no case by government. On an average it has cost about 32s. per acre to bring the water on to the land, and a water-rate is charged of from £2 8s. to £4 per acre, the farmer paying in addition a rate of from 2s. to 10s. per acre annually for maintenance. Distributary channels of less than five feet wide cost less than £100, up to ten feet wide about £150 per mile.

THE INTRODUCTION OF IRRIGATION INTO A COUNTRY.

It is evident that there are many serious considerations to be taken into account before entering on any large project for irrigation. Statistics must be carefully collected of rainfall, of the sources of water supply available, and of the amount of that rainfall which it is possible to store and utilize. The water should be analyzed if there is any danger of its being brackish. Its temperature should be ascertained. It should be considered what will be the effect of pouring water on the soil, for it is not always an unmixed benefit. A dry climate may be changed into a moist, and fever and ague may follow. In India there are large tracts of heavy black soil, which with the ordinary rainfall produce excellent crops nine years out of ten, and where irrigation would rather do harm than good. But in the tenth year the rains fail, and without artificial irrigation the soil will yield nothing. So terrible may be the misery caused by that tenth year of drought that even then it might pay a government to enter on a scheme of irrigation. But it is evident that it might not pay a joint-stock company.

In all cases it is of the first importance to establish by law the principle that all rivers or streams above a certain size are national property, to be utilized for the good of the nation. Even where there is no immediate intention of constructing irrigation works it is well to establish this principle. Otherwise vested rights may be allowed to spring up, which it may be necessary in after years to buy out at a heavy cost.

MODES OF DISTRIBUTING AND ASSESSING WATER.

Where the river is too inconsiderable to be proclaimed as national property, and where there is no question of spreading the water broadcast over the land, but of bestowing it with minute accuracy over small areas to rear valuable plants, such as fruit-trees, it may be very well left to local societies or to syndicates of farmers to manage their own affairs. Where irrigation is on a larger scale, and its administration is a matter of national importance, the control of the water requires the closest consideration, especially if, as is usually the case, the area which may be irrigated exceeds the volume of water available to irrigate it, and where the water is delivered to the fields by gravitation without the labor of raising it. It must be decided on what principle the farmer's right to the water is to be determined. Is he to obtain water in proportion to the area of his land which is irrigable? If part of the irrigable land is not yet cultivated, is some of the supply to be reserved for such land? Is he to pay in proportion to the area actually watered for each crop, or to the area which he might water if he chose? Where the slope of the land is sufficient to allow the water to flow freely out of a sluice into the field channel, it is not difficult to measure the water discharged. Modules have been invented for this purpose, and the owner of the field may

be required to pay for so many cubic feet of water delivered. The government or the association owning the canal will then have nothing to do with the way in which the water is employed, and self-interest will force the farmer to exercise economy in flooding his land. But even then precautions must be taken to prevent him from keeping his sluice open when it should be shut.

In Italy and in America water is generally charged by the module; but in many cases, where the country is very flat, the water can not fall with a free drop out of the sluice, and, as far as I know, no satisfactory module has yet been invented for delivering a constant discharge through a sluice when the head of water in the channel of supply is subject to variation. These are the conditions prevailing in the plains of northern India, where there is a yearly area of canal irrigation of about six millions of acres. The cultivator pays not in proportion to the volume of water he uses, but on the area he waters every crop, the rate being higher or lower according as the nature of the crop demands more or less water.

The procedure of charging for water is, then, as follows: When the crop is nearly ripe the canal watchman, with the village accountant and the farmers interested, go over the fields with a government official. The watchman points out a field which he says has been watered. The accountant, who has a map and field-book of the village, states the number and the area of the field and its cultivator. These are recorded along with the nature of the crop watered. If the cultivator denies that he has received water, evidence is heard and the case is settled. A bill is then made out for each cultivator, and the amount is recovered with the taxes.

This system is perfectly understood, and works fairly well in practise. But it is not a satisfactory one. It holds out no inducement to the cultivator to economize water, and it leaves the door open to a great deal of corruption among the canal watchmen and the subordinate revenue officials.

GOVERNMENT CONTROL OF WATER SUPPLY.

Where the subject agricultural population is unfitted for representative government it is best that the government should construct and manage the irrigation, on rules carefully considered and rigorously enforced, through the agency of officers absolutely above suspicion of corruption or unfair dealing. Such is the condition in Egypt and in the British possessions in India. Objections to it are evident enough. Officials are apt to be formal and inelastic, and they are often far removed from any close touch with the cultivating classes. But they are impartial and just, and I know of no other system that has not still greater defects.

Even if the agricultural classes in India were much better educated than they are, it would still be best that the control of the irrigation should rest with the government. By common consent it is the government alone that rules the army. Now the irrigation works form a great army, of which the first duty is to fight the grim demon of famine. Their control ought, therefore, to rest with the government; but the conditions are very different when the agricultural classes are well educated and well fitted to manage their own affairs.

Irrigation is too new and experimental in America for us to look there for a well-devised scheme of water control. The laws and rules on the subject vary in different states, and are often contradictory. It is better to look at the system evolved after long years in north Italy.

THE ITALIAN SYSTEM.

I have already alluded to the great

Cavour Canal in Piedmont. This fine work was constructed by a syndicate of English and French capitalists, to whom the government gave a concession in 1862. Circumstances to which I need not allude ruined this company, and the government, who already had acquired possession of many other irrigation works in Piedmont, took over the whole Cavour Canal in 1874, a property valued at above four millions sterling, and ever since the government has administered it.

The chief interest of this administration centers on the Irrigation Association west of the Sesia,[2] an association that owes its existence to the great Count Cavour. It takes over from the government the control of all the irrigation effected by the Cavour and other minor canals within a great triangle lying between the left bank of the Po and the right bank of the Sesia. The association purchases from the government from 1,250 to 1,300 cubic feet per second. In addition to this it has the control of all the water belonging to private canals and private rights, which it purchases at a fixed rate. Altogether it distributes about 2,275 cubic feet per second, and irrigates therewith about 141,000 acres, of which rice is the most important crop. The association has 14,000 members, and controls 9,600 miles of distributary channels. In each parish is a council, or, as it is called, a *consorzio,* composed of all landowners who take water. Each *consorzio* elects one or two deputies, who form a sort of water parliament. The deputies are elected for three years, and receive no salary. The assembly of deputies elects three committees—the direction-general, the committee of surveillance, and the council of arbitration. The first of these committees has to direct the whole distribution of the waters, to see to the conduct of the employees, etc. The committee of surveillance has to see that the direction-general does its duty. The council of arbitration, which consists of three members, has most important duties. To it may be referred every question connected with water-rates, all disputes between members of the association or between the association and its servants, all cases of breaches of rule or of discipline. It may punish by fines any member of the association found at fault, and the sentences it imposes are recognized as obligatory, and the offender's property may be sold up to carry them into effect. An appeal may be made within fifteen days from the decisions of this council of arbitration to the ordinary law courts, but so popular is the council that, as a matter of fact, such appeals are never made.

To effect the distribution of the water the area irrigated is divided into districts, in each of which there is an overseer in charge and a staff of guards to see to the opening and closing of the modules which deliver the water into the minor watercourses. In November of each year each parish sends in to the direction-general an indent of the number of acres of each description of crop proposed to be watered in the following year. If the water is available the direction-general allots to each parish the number of modules necessary for this irrigation; but it may quite well happen that the parish may demand more than can be supplied, and may have to substitute a crop like wheat, requiring little water, for rice, which requires a great deal.

The government executes and pays for all repairs on the main canals. It further executes, at the cost of the Irrigation Association, all repairs on the minor canals. The association, then, has no engineers in its employ, but a large staff of irrigators.

[2] See Mr. Elwood Mead's 'Report on Irrigation in Northern Italy,' printed for the Department of Agriculture, Washington, 1904.

The irrigation module employed in Piedmont is supposed to deliver 2.047 cubic feet per second. The association west of the Sesia buys from the government what water it requires at a rate fixed at 800 liras per module, or £15 12s. 7d. per cubic foot per second per annum.

The association distributes the water by module to each district, and the district by module to each parish. Inside the parish each farmer pays, according to the area he waters, a sum to cover all the cost of the maintenance of the irrigation system, and his share of the sum which the association has to pay to the government. This sum varies from year to year according as the working expenses of the year increase or diminish.

I have already mentioned the recently constructed Villoresi Canal in Lombardy. This canal belongs to a company, to whom the government have given large concessions. This company sells its water wholesale to four districts, each having its own secondary canal, the cubic meter per second, or 35.31 cubic feet per second, being the unit employed. These districts, again, retail the water to groups of farmers termed *comizios,* whose lands are watered by the same distributary channels, their unit being the liter, or .035 cubic foot per second. Within the *comizio* the farmer pays according to the number of hours per week that he has had the full discharge of the module.

I have thought it worth while to describe at some length the systems employed on these Italian canals, for the Italian farmers set a very high example, in the loyal way in which they submit to regulations which there must at times be a great temptation to break. A sluice surreptitiously opened during a dark night, and allowed to run for six hours, may quite possibly double the value of the crop which it waters. It is not an easy matter to distribute water fairly and justly between a number of farms at different levels, dependent on different watercourses, cultivating different crops. But in Piedmont this is done with such success that an appeal from the council of arbitration to the ordinary law courts is unheard of. It is thought apparently as discreditable to appropriate an unfair supply of water as to steal a neighbor's horse, as discreditable to tamper with the lock of the water module as with the lock of a neighbor's barn.

MR. SCHUYLER'S VIEWS AS TO GOVERNMENT CONTROL.

Where such a high spirit of honor prevails I do not see why syndicates of farmers should not construct and maintain a good system of irrigation. Nevertheless, I believe it is better that government should take the initiative in laying out and constructing the canals and secondary channels at least. A recent American author, Mr. James Dix Schuyler, has put on record: "That storage reservoirs are a necessary and indispensable adjunct to irrigation development, as well as to the utilization of power, requires no argument to prove. That they will become more and more necessary to our western civilization is equally sure and certain; but the signs of the times seem to point to the inevitable necessity of governmental control in their construction, ownership and administration."

This opinion should not be disregarded. Sir W. Willcocks has truly remarked: "If private enterprise can not succeed in irrigation works of magnitude in America, it will surely not succeed in any other country in this world." What its chances may be in South Africa I leave to my hearers to say. It is not a subject on which a stranger can form an opinion.

C. Scott Moncrieff.

THE AMERICAN ANTHROPOLOGICAL ASSOCIATION.

A SPECIAL meeting of the American Anthropological Association was held in the Department of Anthropology at the Affiliated Colleges of the University of California, San Francisco, August 29–31, 1905.

This, the first meeting of the association ever held west of St. Louis, was presided over by Professor Frederick W. Putnam, Dr. A. L. Kroeber being secretary of the committee on program and arrangements. Dr. Charles Peabody was elected secretary *pro tempore*, in place of Dr. George Grant MacCurdy, the secretary, whose enforced absence was due to injuries sustained in a bicycle accident.

The second day's sessions were held at the California Academy of Sciences; and those of the third day, at the University of California, Berkeley, in conjunction with the California Branch of the American Folk-Lore Society.

COMMITTEES.

Two important committees were appointed by the president, both to report at the next regular meeting. The first of these, consisting of Dr. Charles Peabody (chairman), Professor John H. Wright, Mr. W. K. Moorehead, Mr. F. W. Hodge, Mr. J. D. McGuire, is to investigate the question whether an improvement or a readjustment of the names used in archeology be feasible. The other committee, composed of Mr. F. W. Hodge (chairman), Mr. W. H. Holmes, Dr. Franz Boas, Dr. A. L. Kroeber, Dr. R. B. Dixon, Dr. George A. Dorsey, Mr. James Mooney, is to consider the most desirable nomenclature for Indian families north of Mexico.

The amendments to the constitution, as recommended by the council at its meeting in Philadelphia, in December, 1904, and in New York, in April, 1905, were adopted. The amended constitution, together with abstracts of all the papers read, will appear in the *American Anthropologist* for October–December, 1905.

Fifty-two new members were elected.

EXCURSIONS AND ENTERTAINMENTS.

On Tuesday, August 29, luncheon was tendered the association by Mrs. Phoebe A. Hearst, in the Department of Anthropology at the Affiliated Colleges, San Francisco.

In the afternoon an exhibition of the collections of the department was held. The officers of the department conducted the members of the association through the building and explained the collections.

On Wednesday, August 30, a luncheon was tendered the association by the California Academy of Sciences, at the St. Francis Hotel, Vice-President Alpheus Bull making an address of welcome.

In the evening of August 30, a dinner was given the visiting members of the association by the resident members, at the St. Francis Hotel.

On Thursday, August 31, before the opening of the morning session, Professor J. C. Merriam conducted a party to the Emeryville shell mound, explaining the excavations made in the mound by himself and Dr. M. Uhle.

On the same day, luncheon was tendered the association by Mrs. Phoebe Hearst, in the building of the Department of Anthropology of the University of California, at Berkeley.

After luncheon, the collection of plaster casts illustrative of ancient art was exhibited, as arranged, in this building.

On Friday, September 1, an excursion was made to Mr. Luther Burbank's home in Santa Rosa. This excursion was arranged through the courtesy of Mr. Burbank, the California Promotion Committee and the California Northwestern Railway. Thirty-four members took part.

On Saturday, September 2, an excursion was made to Leland Stanford Junior University. The buildings and grounds were shown the party and luncheon was tendered by officers of the university. Twenty members took part in this excursion.

RESOLUTIONS.

Resolutions, as follows, were unanimously passed by the association: Resolutions expressing appreciation of the courtesy and hospitality of Mrs. Phoebe A. Hearst; of the Academy of Sciences, and of Vice-President Bull and Director Loomis; of the University of California and President Wheeler; of Mr. Luther Burbank; and of the Leland Stanford Junior University; also expressing appreciation of the successful energy and direction of Professor Putnam, president of the association, and of Dr. Kroeber, secretary of the committee on program and arrangements; also by the visiting members, expressing their appreciation of the hospitality of the resident members.

PAPERS READ.

August 29, 1905.

Dr. Frederick Ward Putnam, director of the Museum of Anthropology of the University of California, and curator of the Peabody Museum of Harvard University: 'Exhibition of Bones, Possibly showing the Work of Man, from Quaternary Caves of California.' Discussed by Mrs. Herrick, Hill-Tout, J. C. Merriam.

Mr. Charles Hill-Tout, Ethnological Survey of Canada: 'Heterogeneity of the Culture of the Selish Tribes.' Discussed by Dixon, Goddard, C. Hart Merriam, Kroeber, Barrett.

Dr. C. Hart Merriam, chief of the Biological Survey, Washington, D. C.: 'The Aboriginal Indian Population of California.' Discussed by Mrs. Herrick, McLeod, Barrett.

Dr. R. B. Dixon, Harvard University: 'The Mythology of the Shasta-Achomawi Indians of California.' Discussed by Hill-Tout, C. H. Merriam.

Miss Constance Goddard DuBois, Waterbury, Conn.: 'Mission Religious Myths.' Illustrated with phonograph records. Discussed by C. H. Merriam, Peabody.

August 30, 1905.

Mrs R. F. Herrick, Eureka, Calif.: 'The Indians of Humboldt Bay.' Discussed by Hill-Tout, Keeler, Rust.

Dr. J. C. Merriam, University of California: 'The Exploration of Quaternary Caves in California.' Illustrated with lantern slides. Discussed by Peabody.

Dr. A. Hrdlicka, assistant curator, physical anthropology, U. S. National Museum: 'A Contribution to the Physical Anthropology of California.'

Mr. S. A. Barrett, University of California: 'Presentation of a Map showing the Territory, Divisions, Villages and Camp-Sites of the Pomo Indians of California.' Discussed by C. H. Merriam, Dixon.

Dr. C. Hart Merriam, Washington, D. C.: 'The Chievor of the Tongva, a Mortuary Ceremony.' Discussed by Miss DuBois, Dixon, Hill-Tout.

Mr. P. S. Sparkman, Valley Centre, San Diego County, Calif.: 'The Grammar of the Luiseño Language of Southern California.' Discussed by Hill-Tout.

Dr. Philip Mills Jones, secretary and editor of the Medical Society of the State of California: 'Brief Description of a Method for preserving Shell Specimens.' Discussed by Putnam.

Dr. Charles Peabody and Warren K. Moorehead, Archeological Museum of Phillips Academy, Andover, Mass.: 'The Naming of Specimens in American Archeology.' Discussed by Hill-Tout.

Dr. J. C. Merriam, University of California: 'The Excavations at Emeryville Shell Mound.' Illustrated with lantern slides. Discussed by Dixon, Hill-Tout, Putnam.

Mr. H. N. Rust, South Pasadena, Calif.: 'A Ceremony of the Mission Indians of Southern California.' Discussed by Kroeber, Miss DuBois, Hill-Tout, Putnam.

Dr. A. L. Kroeber, University of California: 'Exhibition of a Basket, now in the California Academy of Sciences, from the Extinct Indians of San Nicolas Island, California.' Discussed by McLeod, Rust.

Mr. F. I. Monsen, San Francisco, Calif.: 'Explorations in Northern Arizona and New Mexico.' Discussed by Putnam.

August 31, 1905.

Dr. A. L. Kroeber, secretary of the department of anthropology, University of California: 'Systematic Nomenclature in American Ethnology.' Discussed by J. C. Merriam, C. H. Merriam, Hill-Tout, Dixon, Peabody.

DR. C. HART MERRIAM, Washington, D. C.: 'Basket Cave Burial in California.' Discussed by McLeod, Putnam.

MR. H. N. RUST, South Pasadena, Calif.: 'The Obsidian Blades of Northern California.' Discussed by Putnam.

MR. S. A. BARRETT, University of California: 'Basket Designs of the Pomo Indians.' Discussed by C. H. Merriam.

DR. P. E. GODDARD, department of anthropology, University of California: 'Mechanical Aids to the Study and Recording of Language.' Discussed by Putnam.

DR. J. C. MERRIAM, University of California: 'Some Suggestions concerning the Origin of the Calaveras Skull.' Illustrated with lantern slides. Discussed by Hill-Tout.

MR. CHARLES KEELER, Berkeley, Calif.: 'Creation Myths and Folk Tales of the Manua Islands, Samoa.' Discussed by Dixon.

MR. J. T. GOODMAN, Alameda, Calif.: 'The Maya Dates.' Discussed by Putnam.

MR. C. C. WILLOUGHBY, assistant curator, Peabody Museum of Harvard University: 'Specimens in the Peabody Museum collected by the Lewis and Clark Expedition.'

MR. H. N. RUST, South Pasadena, Calif.: 'Exhibition of Implements from San Nicolas Island, used for Cutting and Working Shell Ornaments.'

PROFESSOR HOWARD SWAN, Imperial College, Peking, China: 'A Systematic Arrangement for Recording Dialects.'

PROFESSOR W. H. HOLMES, Washington, D. C.: 'Antiquity of Man in North America.' Discussed by Putnam, Peabody, Swan.

DR. F. C. NEWCOMBE, Victoria, B. C.: 'Exhibition of Northwestern Indian Designs.' Discussed by Hill-Tout.

BY TITLE.

MR. CHARLES F. LUMMIS, secretary of the Southwest Society, Los Angeles, of the Archeological Institute of America: 'Old Indian and Spanish Folk Songs of the Southwest.' Illustrated with phonograph records.

MR. C. P. MACKIE, Englewood, N. J.: 'A Plea for the more Critical Use of History in Anthropological Research.'

DR. GEORGE GRANT MACCURDY, Yale University: 'Eoliths from England and Belgium.'

DR. C. HART MERRIAM, Washington, D. C.: 'Basketry of California Indians.'

DR. ALBERT ERNEST JENKS, chief of the Ethnological Survey of the Philippine Islands, Manila: 'The Peopling of the Philippines.'

DR. A. L. KROEBER, University of California: 'Indian System of Consanguinity in California.'

MISS JEANNE ELIZABETH WIER, Nevada State University: 'The Washoe Indians of Nevada.'

DR. N. B. EMERSON, Honolulu, Hawaii: "Introduction to 'Unwritten Literature of Hawaii.'"

MRS. ZELIA NUTTALL, director of the Crocker researches in Mexico for the department of anthropology of the University of California: 'The Earliest Historical Communications between Japan and Mexico, from Original Documents preserved in Archives of Japan, recently brought to Light by a Mexican Diplomat.'

MR. ALVIN SEALE, Leland Stanford Junior University: 'Ceremonies relating to Sickness and Death in the Solomon Islands.'

MISS ALICE C. FLETCHER, Washington, D. C.: 'The Earth Lodge and its Migrations.'

MR. JAMES MOONEY, Washington, D. C.: 'The Cheyenne Indians.'

MR. JAMES MOONEY, Washington, D. C.: 'The Caloosa Tribe of Florida.'

DR. J. R. SWANTON, Washington, D. C.: 'The Social Organization of American Tribes.'

PROFESSOR W. H. HOLMES, Washington, D. C.: 'Architecture of the Aborigines of North America.'

PROFESSOR W. H. HOLMES, Washington, D. C.: 'Use of Copper by the Aborigines of North America.'

PROFESSOR W. H. HOLMES, Washington, D. C.: 'Problematical Objects in the Prehistoric Archeology of North America.'

It was voted that no program be proposed for the meeting of the American Association for the Advancement of Science, at New Orleans, and that the annual meeting be held at Ithaca, New York, in December, 1905.

GEORGE GRANT MACCURDY,
Secretary.

YALE UNIVERSITY MUSEUM,
NEW HAVEN, CONN.

SCIENTIFIC BOOKS.

Evolution, Racial and Habitudinal. By the Rev. JOHN T. GULICK. Washington, Carnegie Institution, August, 1905. 8vo. Pp. xii + 269; 3 pl.

Dr. Gulick for more than thirty years has been an earnest advocate of the importance of segregation of groups of individuals as an

element in the evolution of specific types. His papers have been useful in putting a needed emphasis on a factor which had been insufficiently taken into account and frequently overlooked by theorists concerned with the question of specific evolution. It was appropriate, therefore, that the Carnegie Institution should give him the opportunity of presenting in one handsome volume, the ripened result of his years of reflection and study on this subject.

It is known that his studies were largely due to the interest excited by the beautiful and multiform tree-snails of the Hawaiian Islands, which, for variety in characteristics elsewhere usually taken as of specific value, are unexcelled in any equal area. It was a problem which appealed to every collector of these attractive animals. How should this almost infinite variety under almost identical conditions be accounted for? The latest investigations indicate that the chief food of the arboreal Achatinellas consists of fungoid mycelium which in the warm air and constant rains of the mountainous region of the islands is more or less abundantly developed on the bark of trees and shrubs upon which these landshells live; an examination by Mr. Cook of many stomachs has shown that the leaves of the shrubs or trees form no part of their diet, and that, contrary to the opinions formerly held and even not altogether discarded in the volume under review, the species of tree upon which these animals live is not of importance in their economy; the same species of shell being often found indifferently upon different species of trees over the area the former inhabits. This fact lends even greater importance to the remaining elements of the environment among which the stimulus to variation is to be sought.

It has been found that the Achatinellas do not lend themselves readily to experiment. Removal, even when not the slightest injury has been inflicted, usually proves fatal, from some unexplained cause. It is evident that they are extremely sensitive to even minute changes in altitude, moisture, etc., and attempts to get them to breed in the more accessible regions of the islands, where they could be kept under continuous observation, have so far proved failures. Even the eggs seem unable to bear transportation.

For the reader who wishes to gain quickly an idea of the hypothesis maintained by Dr. Gulick, we should suggest the original papers of which a bibliography is given in the present volume, as they contain the meat of the matter in more concentrated form. In the opinion of the reviewer something has been lost by the considerable expansion of verbiage to which the statement of the hypothesis has here been subjected. But doubtless the special student of these recondite problems will find the volume none too long. In any event it should not be forgotten that while Dr. Gulick's views seem eminently probable and in the reviewer's mind go far toward accounting for many of the facts, nevertheless they are theoretical and have not yet been subjected to the crucial test of experiment, by which the proposed theory in the end must be tested. To justify final acceptation an hypothesis must not only be capable of accounting for the facts but it must be shown to be the only one by which they may be adequately explained. It is also necessary to determine how far the animals in question have arrived at that state of organic equilibrium which we recognize by the name of species. If, as has been held by some authorities, the small color-groups are really only of a temporary nature, and liable to immediate change upon subjection to modified environment, then the author's hypothesis, while losing nothing of its truth, is not a contribution to the evolution of species so much as to the physiology of color-variation. The latter may or may not be, in the group discussed, a factor of specific weight.

In any case we are grateful for the full presentation of the author's views which are of acknowledged importance in the discussion. The volume is well printed, though we could have wished that the colored plates had been of a better quality.

W. H. Dall.

Marceli Nencki Opera Omnia. Gesammelte Arbeiten von Professor M. Nencki. Braunschweig, Friedrich Vieweg und Sohn. 1905.

Two volumes, with a portrait of the author. Pp. 840 + 890.

The influence which an untiring worker like Professor Nencki exerts on the development of science is perpetuated in at least two ways. The enthusiasm of the investigator is transmitted to his pupils and thus continues to live; and his definite contributions to knowledge are recorded in books which do not die with the author. With the methods of publication adopted in scientific circles of the present day, the researches of an individual are usually scattered in many papers and numerous journals. What this may mean in the course of thirty years of unceasing labor in the advancement of learning is illustrated in the case of Nencki's published work, embodying his studies in organic and physiological chemistry, in bacteriology, hygiene and pharmacology, presented in many places and in several languages. Nencki's interest continued to center in the chemical aspects of various allied branches of biological and medical science, although his writings are not strictly limited by such definition. No résumé or critical discussion of the literature of urea formation and the behavior of aromatic compounds in the animal body, of the chemistry of putrefaction, of the composition of the blood pigments, of the chemistry of various digestive secretions and processes and the activity of enzymes, would be at all adequate without reference to his published contributions. Furthermore, this does not take into account Nencki's many valuable investigations in organic chemistry and hygiene.

In view of what has been stated, and especially the personal circumstances which led to such diverse channels of publication, it is timely and appropriate that the life-work of this distinguished physiological chemist should be collected and presented in a more readily available form, thus supplying what an untimely death prevented on the part of the late scientist; and it is, indeed, fortunate that two pupils so well known and closely associated with Nencki as N. Sieber and J. Zaleski have undertaken the compilation of his collected works. The two volumes which they have edited embrace all of Nencki's scientific papers, together with abstracts of such investigations as were directly inspired by him and conducted under his supervision. A detailed reference to the papers would interest the specialist alone; but the array of contributions appearing in uninterrupted succession from 1869 to 1901 is an impressive monument to industry. A brief biographical sketch of the author is included in the volumes, which are of quite unusual typographical excellence.

LAFAYETTE B. MENDEL.
SHEFFIELD SCIENTIFIC SCHOOL OF
YALE UNIVERSITY,
NEW HAVEN, CONN.

Manual of Chemical Analysis as Applied to the Assay of Fuels, Ores, Metals, Alloys, Salts and other Mineral Products. By EUGÈNE PROST, D.Sc., of the University of Liège. Translated by J. CRUICKSHANK SMITH, B.Sc., F.C.S. Large 8vo. Pp. 300. Price $4.50. New York, D. Van Nostrand Company. 1905.

The work comprises a short introduction on the 'preparation of samples for analysis,' nearly two hundred pages on the analysis of fuels, waters and various native and artificial chemical compounds, and one hundred pages on the analysis of metals and alloys. According to the author's preface, it is intended as a manual for the industrial chemist.

Viewing the book in the light of its intended usefulness, our verdict upon it is that it is as nearly superfluous a work as could be written. The plan is fragmentary, many important analyses are omitted; the directions are poorly expressed, in most cases insufficient and in many inaccurate; obsolete methods are mixed in with more modern ones without criticism or discrimination; there is scarcely to be found a single reference to any other works on analysis or journals of any kind, to supplement the fragmentary information given; the translator was evidently as little fitted for his task as the author, as is evident from poorly translated phrases which betray an ignorance of English chemical expressions and especially of metallurgical terms; the paper is wretchedly poor, the bind-

ing flimsy, the typography bad, the cuts miserable.

The reviewer is not suffering from either indigestion or disordered liver, and on taking second thought is convinced that the above estimate is not undeservedly harsh.

JOSEPH W. RICHARDS.

Histoire de l'habillement et de la parure. By L. BOURDEAU. 1 vol. 8vo. Bibliothèque scientifique internationale. Paris, Felix Alcan. Pp. 300. 6 francs.

This volume completes a series of culture-historical studies by the author: The forces of industry, the history of alimentation, the conquest of the animal kingdom, the conquest of the vegetal kingdom, and history of dress and adornment. Three motives are urged as having given rise to vestment—protection from injury caused by the things that are without, the love of pleasure and modesty. The male sex and the female have vied with each other in the elaboration of innumerable inventions in this category. Animals have clothing provided by nature—carapaces, shells, hair, bristles, feathers, down, wool and more. Man's skin, on the contrary, is a tissue of sensation structures, putting him into lively contact and communication with the outside world, but shielding him little.

The unfolding of this story is divided into two parts: (1) the materials—skins and textile substances and their preparations, and (2) the history of costume. The substances fit for clothing are not innumerable. They had to be bad conductors of heat from the body and to the body; they had to be pliable, fitting themselves to the form, tough enough to wear and last and pay for the time spent in manufacturing them. The story begins with skins and passes on through animal textiles, vegetal textiles and other substances, from which must not be omitted the great variety of things ornamental. Add to all this the fashions in tissues, the dyeing, staining, painting, bleaching, printing of patterns on goods, cutting out, sewing and trimming, and it will appear what a large fraction of human hours are given to raiment. The making of buttons requires the services of 30,000 workmen and an outlay of 30,000,000 francs (1900).

The development of costume fills the last one hundred pages, its general evolution, the special history of modern costume, head dresses, foot gear and gloves, accessories of costume, such as handkerchiefs, fans, parasols, umbrellas and jewelry. There is a chapter (pp. 124–147) on artificial coloring of the hair and skin, tattooing, painting and dyeing. And the goodly friend of the species, soap, together with perfumeries, baths, etc., is not neglected. It is a great pity that there is no index to the work, for there is an infinite amount of petty detail gathered here, to which one would like to refer. The author assumes the existence of naked and unadorned peoples. When you go to look for them, they are seldom to be found, which leads to the inquiry whether really there are any such. O. T. M.

SCIENTIFIC JOURNALS AND ARTICLES.

The Journal of the American Chemical Society for November contains the following articles:

ROY D. HALL and EDGAR E. SMITH: 'Some Observations on Columbium.'

JOSEPH H. GOODWIN: 'Electrolytic Calcium.'

GEO. A. HULETT: 'Preparation of Nitrogen from the Atmosphere.'

H. M. GORDIN: 'On the Crystalline Alkaloid of Calycanthus Glaucus.'

WILLIAM A. NOYES and HOWARD W. DOUGHTY: 'Derivatives of Trimethylparaconic and of Camphoronic Acids.'

EDWARD GUDEMAN: 'Artificial Digestion Experiments.'

A. T. LINCOLN: 'A New Burette Holder.'

Review of American Chemical Research.

The Museum News, of the Brooklyn Institute, for November may be termed a zoological number, as it is principally devoted to notes pertaining to that branch of science. There is a little leader in the matter of labels, which explains why labels are frequently absent, and also gives the point of view of the curator. The completion of a group of fur seals is announced which has been in preparation for some time, and is the finest of its kind in any museum, comprising as it does thirteen speci-

mens, representing the various classes of this valuable animal. The leading article in the Children's Museum section is a sketch of 'King Cole,' a live crow, which was for some time an object of interest in the museum. Lecture courses are announced for both museums.

SOCIETIES AND ACADEMIES.

THE ELISHA MITCHELL SCIENTIFIC SOCIETY OF THE UNIVERSITY OF NORTH CAROLINA.

THE 161st meeting of the society was held in the chemical lecture room on Tuesday (7:30 P.M.), October 17, 1905. The following papers were presented:

PROFESSOR H. V. WILSON: 'On the Formation of Regenerative Bodies of Sponges when kept in Confinement.'

PROFESSOR A. S. WHEELER: 'Paper Making.'

ALVIN S. WHEELER,
Recording Secretary.

DISCUSSION AND CORRESPONDENCE.

MUSICAL INSTRUMENTS OF MALAYSIA AND THE WEST COAST OF AMERICA.

TO THE EDITOR OF SCIENCE: A short time ago the National Museum received from Mr. C. Boden Kloss, curator of the Johore Museum, No. 40 of the *Journal of the Straits Branch of the Royal Asiatic Society,* for June, 1904, containing an illustrated catalogue of the ethnographical collection of the Sarawak Museum, Part I., Musical Instruments, by R. Shelford.

On page 29, Mr. Shelford thus describes a flageolet of the tribe called Murut, in Borneo:

a. Murut—Flageolet. (Plate VIII., figs. 7 and 8.)

Distal end open and cut square, proximal end closed by the natural septum, the bamboo has not been cut flush with this but projects considerably beyond it; in the wall of this projecting part a small hole is bored quite close to the septum, and a groove runs on the outside of the flute from this hole to the sound-hole, the groove being covered by a slip of bamboo luted on with dammar. The edge of the sound-hole is sharpened by a piece of palm-leaf stuck on. The sound-hole is 5 centim. from the proximal end; there are two stops 8.5 centim. apart, bored with a red-hot iron in a flattened strip on the same side as the sound-hole, the upper one is 32 centim. from the sound-hole. Total length 52.5 cm.; diam. 2.5 cm.

Catalogue No. 1291. F. J. D. Cox, Esq. (P. viii 03). From the Trusan river.

This is precisely similar to the mystery flute of some of the early writings about the North American Indians. The Museum has just received an additional example from Arizona, through E. H. Nelson. They are usually made of cane, having a closed joint at or near the middle. A hole is pierced on either side of the septum of the joint through the walls of the cane and an air channel cut on the outside from one hole to the other. If the upper hole and the channel are covered by a bandage or the finger as far as the lower face of the septum and the upper tube blown into, it gives a whistling sound. In the lower section three or four finger holes are made. If more than that number, it shows a European influence. If an instrument of this kind that has no bandage is handed to one ignorant of its characteristics, he would not be apt to place a finger in the precise spot required to make a sound, and how to sound it would be a mystery to him. Some of the North American Indians construct bone whistles in the same manner. For the reason that this method of construction is seldom seen elsewhere, the instrument is supposed to have been original with the Indians of North America.[1]

This is another interesting connecting link between Malaysia and the west coast of America, because of these two identical instruments in regions far apart. A search for the cause of this identity will be interesting to ethnologists. E. H. HAWLEY.

THE BUREAU OF SOILS.

TO THE EDITOR OF SCIENCE: Mr. F. H. King, in the last number of SCIENCE, reviewing the work done by Dr. Buckingham and published by the Department of Agriculture, makes use of the following expression:

He is well aware too that my object in having him called to the bureau was that he might make

[1] See George Catlin Indian Gallery, Smithsonian Report, 1885, p. 395 and Plate 93 g.

investigations along exactly the lines printed in the Bulletin, with many others, but to have him do so in conjunction with simultaneous field studies * * * etc.

To one who is unacquainted with either party to the controversy, on the nature of which he is also very little posted, the following questions naturally arise:

1. By what uncharted route under the civil service did Dr. Buckingham reach his present position in the Department of Agriculture?

2. Does one who secures a position in the department by the means implied, consider himself owned by one outside of the department, so that the latter shall complain, 'Is the creature greater than the creator?'

3. Is Dr. Buckingham owned in Madison, Wisconsin?

Arthur John Hopkins.

October 22, 1905.

SPECIAL ARTICLES.

THE METHOD OF ELIMINATION IN FIXING GENERIC TYPES IN ZOOLOGICAL NOMENCLATURE.

One of the most perplexing problems in zoological nomenclature is to decide on the proper application of a generic name used in a comprehensive sense by an early author, to one of the component parts of the original group. The genus of Linnæus and his followers of the eighteenth century corresponds fairly to the family of the twentieth century. It is agreed that a generic name should stand or fall by its typical species. But the writers of the eighteenth century had little conception of type-species in the modern sense. We must, therefore, find some method of fixing their types for them.

This may be done by choosing the 'best known European or officinal species,' to quote an expression attributed to Linnæus. When such a species is clearly indicated, this ought to settle the matter. But it does not do so in all cases, as some genera have no species either European or officinal. As many of the earlier writers took Linnæan specific names for their genera (tautonomy), it is safe to regard such a practise as fixing the type in question. *Bodianus bodianus* is an example of this sort. Virtual tautonomy (as *Tetrao tetrix*, *Scomber scombrus*) amounts to the same thing.

The method of beginning with a leading species or *chef de file*, as typical representative of each genus to be described in full, while the others were disposed of in comparative sentences, was adopted by Lacépède, Cuvier, Valenciennes, Poey and other authors. In ichthyology this has given reason for the choice of the type of the genus by page precedence. This method was raised to the dignity of a universal rule by Dr. Bleeker and others. It is a pity that it was not systematically adopted earlier, for it would have given fixity, a matter which in nomenclature far outweighs all others. But Linnæus, among others, usually placed his type-species in the middle of the series, the less known or more aberrant forms at either end of it.

The rule of the first reviser is generally recognized, and is given precedence over all other methods of fixing the type by many authors. The objection to it is that no one has yet defined the first reviser, so as to separate his rights from the rights of different meddlers. If we admit none to be revisers, unless they definitely limit a genus and definitely associate its name with some one or more of its original constituent species, to the exclusion of others, this rule may be available, although its application involves a good deal of otherwise profitless labor in bibliography.

In recent years a rule of fixing types by elimination has come into vogue, the American Ornithologists' Union having given it especial prominence. As a guide to the operations of a first reviser, who finds no type assigned by previous writers, the rule is not open to serious objection.

But it has been largely applied without regard to previous revisers, and the meanings of various generic names have been frequently shifted in accordance with its supposed demands. It is evident that it is in great need of definition.

For example, let *A*, *B*, *C*, *D* represent the species of a comprehensive genus called *X*. If each of these is successively made the type of a new genus *U*, *V*, *Y*, *Z*, then *Z*, the last

of these, is invalid and its type, *D*, becomes the proper type of *X*. This is the simple condition of the problem. But let *A* and *C* be set off to form a new genus; *C* and *D*, another. Let a new genus be formed which would probably include *B* in it. Let still another be framed which might possibly include *D*. Let it be further uncertain whether *A* and *B* should be placed in different groups. Let still another writer definitely connect the old genus with *A*, while another uses it, not for any of its constituents, but for some new form probably congeneric with *B*, and you have a not unusual statement of the problem.

There is no way out of this by the rule of elimination. By accepting the first reviser rule, itself subject to the Linnæan rule and the rule of tautonomy, we may well fall back on the rule of page precedence, and let the rule of elimination be simply a recommendation to the first reviser, without direct validity of its own. This is the position of the rule of elimination in the new International Code.

I give two concrete illustrations of the difficulties of the rule of elimination among genera of fishes.

The genus *Clupanodon* Lacépède, 1803, was based on 'toothless herrings,' the *chef de file* being *Clupanodon thrissa*. This species as described by Lacépède, is the *Clupea thrissa* of Broussonnet, the American species, later called *oglinus* by Le Sueur. This is, however, not the original *Clupea thrissa* of Linnæus, 1758, which was based on the *Clupea thrissa* of Osbeck, 1757, a Chinese species, later called *Clupea nasus* by Bloch, a species of *Konosirus*. The second species of Lacépède, *nasicus*, is the same as *Clupea nasus* of Bloch. The third, *pilchardus*, is the *Clupea pilchardus* of Linnæus, a species of *Sardinia*, which is probably the same as *Sardinella*. The fourth species of Lacépède, *sinensis*, is apparently the species called later *Clupea ilisha*, and is probably not the original *sinensis* of Linnæus. It is a species of *Clupeonia* or *Harengula*. The fifth, *africanus*, is a species of *Ilisha*, and the sixth, *jussieui*, is the original type of the genus *Clupeonia*.

Arranging these according to the modern genera:

1. *thrissa*. The type of *Thrissa* Rafinesque, 1815, the name given as a substitute for the hybrid name *Clupanodon*.
   Chatoëssus Cuvier, 1817, based on Lacépède's *thrissa*, the generic name later transferred by Valenciennes to *punctatus*, the *thrissa* of Linnæus.
   Opisthonema Gill, 1863, based on *thrissa* of Lacépède = *oglinus* of Le Sueur.
   Konosirus Jordan & Snyder, 1900, based on *punctatus* Schlegel, which is a congener of *Clupea thrissa* Linnæus (= *Clupea nasus* Bloch) and not of *Clupanodon thrissa* Lacépède, which is *oglinus* of Le Sueur. Most writers unite *Konosirus* with *Dorosoma* Rafinesque, 1829; but the two are probably distinct.
2. *nasicus*. This is the original *thrissa* of Le Sueur and is congeneric with *Konosirus punctatus*.
3. *pilcharus*. This has never been made type of a genus. It is certainly congeneric with *Sardinia* Poey, 1870, with *Amblygaster* Bleeker, 1855, and I now think with *Sardinella* Valenciennes, 1845. Most writers (wrongly I think) unite all these with *Clupea* Linnæus, 1758.
4. *sinensis*. This is referred by Valenciennes to *Clupeonia* Valenciennes, 1845; which genus is probably identical with *Harengula* Valenciennes, 1845, earlier page. Most writers (I think wrongly) place it in *Clupea*.
5. *africanus*. This is congeneric with the type of *Ilisha* Gray, 1836, and with that of *Pellona* Valenciennes, 1845. It has never been taken as type of a genus.
6. *jussieui*. Type of *Clupeonia* Valenciennes, 1845, apparently congeneric with types of *Harengula* and *Kowala* of the same author on earlier pages. Usually referred to *Clupea*.

By the first 'reviser' after Lacépède, Rafinesque, 1815, *Thrissa* is substituted for *Clupanodon*, and Lacépède's *thrissa* is doubtless to be taken as Rafinesque's type. By the next, Buchanan, 1822, *ilisha* (= *sinensis* Lac.) is described as a new species of *Clupanodon*. The genus *Clupanodon* then dropped out of notice until revived by Dr. Jordan in 1882, by a process of elimination for *Clupeonia jussieui*. Later the same writer, by another process of elimination, substituted *Clupanodon* for *Sardinia*. Still later, by the same process with further light, the newly defined genus *Konosirus*, being congeneric with *Clupanodon*

nasicus, was suppressed in favor of *Clupanodon*. The change of result depends on the status assigned to *Konosirus*, *Sardinia* and *Clupeonia*. By the process of elimination the name *Clupanodon* can be used for any one of several species, its use depending on the views one may hold of these closely related generic or subgeneric types. If restricted to the *chef de file*, the matter is at once settled. The species involved become:

Clupanodon oglinus.
Konosirus thrissa.
Sardinella pilchardus.
Harengula ilisha.
Ilisha africana.
Harengula jussieui.

The rule of the first reviser, if the rule of the *chef de file* be disregarded, would cause *Clupanodon* to replace *Harengula*, *Clupeonia* and *Kowala*, *jussieui* being its type.

Another illustration is taken from the genus of flounders, *Pleuronectes* Linnæus, 1758.

In this genus, the European species mentioned by Linnæus and by Artedi, from whom the genus is derived, are:

hippoglossus (type of *Hippoglossus* Cuvier, 1817).
platessa (type of *Platessa* Cuvier, 1817).
flesus (type of *Flesus* Moreau, 1873, a genus very close to *Platessa*, perhaps, in fact, identical).
limanda (type of *Limanda* Gottsche, 1835).
solea (type of *Solea* Quensel, 1803, of *Solea* Rafinesque, 1810, and of *Solea* Cuvier, 1817).
rhombus (type of *Rhombus* Cuvier, 1817, name preoccupied: of *Rhomboides* Goldfusz, 1820, substitute name; also, as *Bothus rumolo*, the first species named under *Bothus* Rafinesque, 1810).
maximus (type of *Psetta* Swainson, 1839, not *Psettus* Cuvier, 1817; first species named of *Scophthalmus* Rafinesque, 1810, which includes also *rhombus*).
passer (a synonym of *flesus*).

Scophthalmus and *Bothus* are based on three species each, the two categories being essentially the same, *Scophthalmus* being based on literature, *Bothus* on specimens. But the order is changed in the two cases, *maximus* occurring first under *Scophthalmus*, *rumolo* (*rhombus*) under *Bothus*. Under *Rhombus* and *Bothus* and *Scophthalmus*, both *maximus* and *rhombus* are included, and *Psetta*, although based on *maximus* alone, by implication is a substitute for *Rhombus*.

The first reviser, Rafinesque, 1810, leaves no species in *Pleuronectes*, unless, as he refers all the other species to other genera, we might regard *hippoglossus*, which is not mentioned by him as the type of his *Pleuronectes*. The next reviser, Cuvier, 1817, recognizes the genus, *Pleuronectes* as used by Linnæus, but at once separates it into four genera or subgenera dropping the original name. These are *Platessa* (*platessa*, *flesus*, *limanda*), *Hippoglossus* (*hippoglossus*), *Rhombus* (*maximus*, *rhombus*) and *Solea* (*solea*). Meanwhile *Solea* had been set off previously by Quensel (1803) and by Rafinesque (1810), the latter author very erroneously referring to it, *platessa*, *flesus* and *limanda* also. Swainson, 1839, the next reviser, recognizes *Pleuronectes* (*platessa*), *Hippoglossus* (*hippoglossus*), *Psetta* (*maximus*) and *Solea* (*solea*). This is the first restricted use of *Pleuronectes* since the time of Linnæus and his followers. Later *Pleuronectes* was restricted by me to *maximus* by the rule of elimination, *flesus* being then regarded, as it is still regarded by most authors, as congeneric with *platessa*. *Limanda* is also near *platessa*. But neither *limanda* nor *flesus* is the 'best known European species' of the Linnæan genus *Pleuronectes*. The rule of the first reviser would fix *Pleuronectes* with *platessa*, the rule of the best known species with *platessa* or *maximus*, the rule of elimination would place *flesus* as type of *Pleuronectes*, if defined as dealing with a species at a time. But Rafinesque took out *solea*, *platessa* and *flesus* together, to form his genus *Solea*, leaving only *hippoglossus* not provided for. This fact, some would hold, restricts *Pleuronectes* to *P. hippoglossus*. Cuvier next took out all the species, leaving no genus *Pleuronectes*, and placing *Rhombus* last, next to *Solea*. On the other hand, *platessa* was placed first by Cuvier, its subgenus *Platessa* being apparently the *chef de file* subgenus in Cuvier's genus *Pleuronectes*.

With this group nothing in particular can

be settled by the process of elimination unless we agree beforehand as to whether *Flesus* is a valid genus, or as to what were the unexpressed purposes of Rafinesque.

But common usage and common sense agree in placing *platessa,* the common Plaice, as the type of *Pleuronectes.*

DAVID STARR JORDAN.

AN INTERESTING CRETACEOUS CHIMÆROID EGG-CASE.

ALMOST nothing is known of the structural characteristics of the holocephalous fishes of the Mesozoic period except dental plates or teeth. The remains of such, however, are numerous and about a score of generic names have been proposed for them, although A. Smith Woodward only fully recognizes five, *Ganodus, Ischyodus, Edaphodon, Callorhynchus* and *Elasmodectes.* I was, therefore, much interested in a fossil which Drs. Frank H. Knowlton and T. W. Stanton referred to me for identification, if possible, and which I at once recognized as a chimæroid ovicapsule apparently most nearly resembling that of modern deep-sea forms.

The interest arises from the assumption that where likeness prevails between such products, not only the parts which frame them but other structures must correspond. The inference is not irrefragable, but in the absence of contradictory data, perfectly legitimate as a provisional hypothesis at least.

The fossilized egg-cases previously known are few and the indications as to affinities interesting as well as important. Three figures have been published of Jurassic egg-cases, two by Emil Bessels and one by Otto Jaekel. All are of the *Callorhynchus* type and it is significant that a 'right palatine tooth,' obtained from the 'Lower Greensand' of New Zealand, has been attributed by E. T. Newton and Woodward to that genus and named *Callorhynchus hectori.*

The newly found fossil was obtained by Mr. N. H. Darton, of the U. S. Geological Survey, from 'massive sandstone' a few miles west of Laramie, Wyoming.

The contour and general form are well preserved but not the details. The resemblance to the ovicapsules of *Harriotta* and *Rhinochimæra* lies in the absence of differentiation between the anterior and posterior portions of the lateral alæ of the capsule and the uniformity of the transverse costal ridges all through. It differs from the ovicapsules of both *Harriotta* and *Rhinochimæra* by the greater width of the alæ and especially the greater width and extension forward along the sides of the archidome.[1] The resemblance is greatest to *Rhinochimæra.*

The genus *Harriotta* was set apart as the type of a subfamily (Harriottinæ) by Gill, in 1896, and it was associated with *Rhinochimæra* in a family (Rhinochimæridæ) by Garman, in 1904. It is to this group (if a family, properly nameable Harriottidæ) that the Wyoming fossil belongs. It can not be correlated with any one of the many generic names (*Eumylodus, Mylognathus, Dipristis, Sphagepœa, Diphrissa, Bryactinus, Isotænia* and *Leptomylus*) that have been especially coined for American Cretaceous fossils, but the naming of it, if such must be done, I leave to Dr. Dean who is now publishing (through the Carnegie Institution) an elaborate work on the chimæroids. I have had the privilege of looking over the proof-sheets of that work and my knowledge of the ovicapsules of the Harriottidæ is chiefly derived from it, though I had long ago seen those of *Harriotta.*

If these determinations prove correct and the groups named families by Garman are accepted as such the curious deduction follows that no fossil ovicapsule of a typical chimærid has been found as yet.

Although the living harriottids are deep-sea forms, it does not follow that a deep sea is indicated for the habitat of the extinct harriottid. The character of the sandstone as well as of the basin in which the ovicapsule was found is opposed to the hypothesis of a deep sea. It must be remembered, too, that the same genus may have species ranging from shallow water to abyssal depths; *Chimæra,* for example, has a species (*C. colliei*) which may be caught from a city wharf and

[1] In the interest of conciseness of description I would use *archidome* for the chamber for the head and trunk of the chimæroid and *urodome* for that receiving the caudal portion.

another (*C. affinis*) which may descend to a depth of at least 1,300 fathoms.

THEO. GILL.

ELECTROMETER FOR THE STAGE OF THE MICROSCOPE.

THE capillary electrometer consists of a vertical tube drawn out at the lower end into a fine capillary and filled with mercury (Figs. 1 and 2). The upper end of the tube is joined to a cylinder in which a piston is

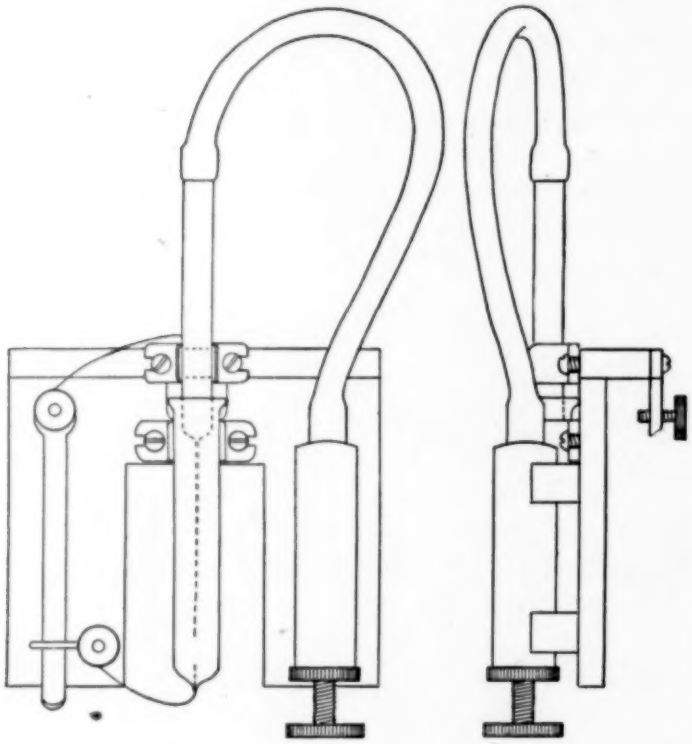

FIG. 1.

FIG. 2.

moved by a screw, thus making pressure on the mercury column. The end of the capillary dips in a reservoir containing 20 per cent. sulphuric acid. A little mercury is placed in the reservoir. Platinum wires lead from this and the mercury in the capillary to convenient binding posts. When mercury is placed in the vertical tube it enters the capillary until the weight of the column of mercury is balanced by the surface tension. If the capillary be now dipped in the reservoir containing the sulphuric acid and the piston driven upward by its screw, mercury will be forced out of the capillary into the acid, and on lowering the pressure the mercury will retreat within the capillary, drawing the acid after it. As the mercury in the capillary is kept from falling by the surface tension, it is obvious that whatever increases or diminishes the surface tension, for example an electric current, will raise or lower in corresponding measure the mercury in the capillary. The alteration in surface tension is accompanied by the movement of ions between the meniscus and the remaining electrode of the electrometer (the mercury in the acid reservoir). In practise it is found that this movement can be neither very rapid nor long continued, without injuring the sensitiveness of the instrument. The potential difference from even a single element (Daniell or dry cell) is far too large to be used safely. It is advisable to employ a potential divider, or rheochord, which shall permit only a fraction of the original potential (not more than 0.1 volt) to reach the electrometer.

The electrometer should be kept short-circuited, except during an observation, so that the capillary and the mercury in the reservoir may always be connected through a conductor. The short-circuit key is shown in Fig. 1. A strip of spring brass connected with one of the binding posts of the electrometer rests against a second piece of brass connected with the other binding post, except when depressed by the finger. The point of higher potential, when known, should always be connected with the capillary.

When the capillary electrometer is connected with two points of unlike potential the meniscus is displaced. The pressure necessary to bring it back to its original position is proportional to the electromotive force that displaced the meniscus. Thus by connecting the electrometer with known differences of potential it may be experimentally graduated. In practise, the relation between the pressure and the potential must frequently be redetermined. It is usually easier to measure differences of potential, such as the demarcation current of nerve or muscle, by compensation. In this method the electromotive force of the demarcation current is measured in fractions of a Daniell cell, or any other constant element, by bringing into the same cir-

cuit with the current of injury, but in an opposite direction, so much of the current from the cell as will exactly balance the current of injury, *i. e.*, so much as will keep the meniscus of the electrometer from moving in either a positive or a negative direction when connected with the circuit.

Numerous advantages are presented by the form of electrometer here shown. It fits the stage of the microscope. The microscope need not be tilted very far, and the observer is therefore in a comfortable position. The position of the electrometer on the stage may readily be changed. All the parts near the acid are of hard rubber, thus excluding currents that might arise from acid touching metal parts. The acid tube is flanged so that the acid can not creep out along the capillary tube. The capillary can easily be brought against the wall of the acid tube. The tube from which the capillary springs descends within the acid tube, thus protecting the capillary against breakage. Either tube may at once be removed from its holder. The platinum wires extend to the binding post, and are not simply short pieces soldered to copper wire. The wire to the capillary tube extends to the bottom of the tube, thus maintaining the contact until all the mercury in the tube is used.

About one cubic centimeter of paraffin oil should be placed above the piston. Only absolutely clean double-distilled mercury should be used.

W. T. PORTER.
HARVARD MEDICAL SCHOOL.

QUOTATIONS.

RESEARCH WORK IN GREAT BRITAIN.

EXPLAIN some remarkable discovery of pure science to the ordinary man and he instantly wants to know what is the use of it or casts about for some way of utilizing it for profit. He neither understands very clearly how the discovery was arrived at nor the importance it possesses apart from immediate application to the meeting of daily wants. Yet nothing is more certain than that the applications of science which most fully subserve the wants of man depend in every considerable case upon the results obtained by men who had no practical application in view. He who finds out merely for the sake of finding out everything that can be known about a given subject has so far contributed to laying the foundations of advance as it is understood by the practical man. Without the discoveries thus made the practical man finds himself balked at every turn. For practical applications depend upon the combination of a great many factors, and demand a power of selection from a vast body of ascertained facts which are supplied only by the seeker after knowledge for its own sake. Of the knowledge thus acquired no man can say what part will be first utilized, or how long any portion may remain useless for practical purpose. That depends very much upon the progress made by research in other directions, hence many important results have been lost to sight merely because some link was missing in the chain connecting them with other known facts. In that case they have to be rediscovered, otherwise they in turn become the missing links, and for want of them other knowledge remains sterile.

Now it is too true that in this country, as Professor Nuttall complains, research is not a career. Pure science does not bring bread and butter. This country has often been fortunate in having men of means who devoted themselves to research for the love of truth, and it has had men like Faraday, of great simplicity of life, who were not merely content, but glad, to live on the income of a clerk while making discoveries that subsequently changed the face of society. But we can not depend upon a constant and adequate supply of either type. The field is now very large and very costly to work. There are many temptations to turn aside which we must expect to be too much for most men who do not possess compelling genius. Hence, if we do not provide a living wage and adequate equipment for a sufficient number of seekers after knowledge, we must expect to be beaten in practical affairs by nations which better understand their true interests. The London school loses promising men who go into practice. In one way or another every branch of research loses promising men, who either go into

practical affairs with what knowledge they have or make research itself subservient to money-getting by selling crude inventions, by self-advertisement, or by cooperation with financiers. We have no hierarchy of students on a living wage basis; and as a consequence we are very short of real teachers even for practical purposes. For the real teacher must be an advanced student, not a mere parrot reciting other men's work.—The London *Times*.

FALLS OF METEORS.

Dr. Edward S. Holden, of the U. S. Military Academy, has kindly sent us the following letters for publication:

A large meteor appeared at Leoti, Kans., between the hours of nine and ten the night of September 2. The sky was clear and the air cool. The meteor, or fire ball, appeared in the west at an angle of about forty-five degrees, crossed the heavens with a hissing sound and was lost in the east, about ten degrees above the sky line. It seemed large as a full moon, with ragged edges. For a moment everything was flooded with light. I think a full minute passed before thundering began in the east and following the path of the meteor across the heavens slowly died out in the west. I have seen meteors in this country at different times, but none as large or followed by thunder.

October 9, 1905. M. A. Marston.

A meteor is said to have fallen some years ago about fifty miles from here beside White Whale Lake. It is near an Indian reservation, and the Indians profess to have seen it fall, and hold it in a good deal of reverence. I have not yet seen the object, * * * I drove out to see the stone this summer, but found that it meant a long row up the lake in a very indifferent boat, so I put the excursion off till the ice comes, when it will be possible to drive right to the spot. Are there any observations that I could make upon this meteor, if it proves to be such, that you would care to have? If so, kindly let me know.

Chas. H. Huestis.

Edmonton, Alberta,
October 5, 1905.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY AND HARVARD UNIVERSITY.

We learn from the Boston *Transcript* that Harvard University has now formally abandoned all plans for a merger with the Massachusetts Institute of Technology. This action was taken at a meeting of the president and fellows on October 30, when the following letter was presented:

My dear President Eliot:

I am directed by the Corporation of the Institute of Technology to communicate to you the fact that, in view of the recent decision of the Supreme Court of the State in the case of John Wilson et al. *vs.* The Massachusetts Institute of Technology, the Corporation of the Institute finds it impossible to proceed with the plan of cooperation which was considered at its meeting of June 9.

In communicating this fact the corporation desires at the same time to express its appreciation of the fairness and courtesy of the Corporation of Harvard University in our common effort to solve a difficult question.

I am,

Very sincerely yours,

[Signed] Henry S. Pritchett,
October 11, 1905. *President.*

Thereupon it was voted that the committee of conference appointed by the Harvard board on May 16, 1904, at the instance of the corporation of the Massachusetts Institute of Technology, be discharged, and that the president be requested to express to the members of the two committees of conference the high appreciation by the president and fellows of the foresight, good judgment and public spirit of which the committees' project for a close affiliation between the institute and the university gives evidence, and the regret of the president and fellows that the project has been brought to naught by the recent decision of the supreme court, which makes it impossible for the institute to place itself beside the university.

SCIENTIFIC NOTES AND NEWS.

The Bolyai prize of the Hungarian Academy of Sciences, of which some account was recently given here, has been awarded to M. Poincaré.

THE eightieth birthday of Dr. F. A. March, professor of English and comparative philology at Lafayette College, was celebrated on October 25, when Professor W. B. Owen made an address of congratulation. The trustees of the college have offered to retire Professor March with full salary, but he prefers to continue his usual duties.

DR. ARTHUR STÄHLER, assistant in the chemical laboratory of the University of Berlin, has been sent by the minister of education to Harvard University to pursue studies in inorganic chemistry under Professor T. W. Richards.

MR. HENRY S. DRINKER, recently installed as president of Lehigh University, was given the degree of Doctor of Laws by Lafayette College on October 25.

DR. EDWARD MARTIN, director of the Department of Public Health and Charities of the city of Philadelphia, has resigned this position.

DR. WILHELM WUNSTORF has been appointed district geologist in the Berlin Geological Bureau.

MAJOR LACHLAN FORBES has been appointed secretary of the Royal Scottish Geographical Society in succession to Major Lindsay Forbes.

THE special board for biology and geology has nominated Mr. F. A. Potts, B.A., of Trinity Hall, Cambridge University, to use the university table at Naples for six months.

DR. THEODOR PREUSS, of the Berlin Museum of Ethnology, has been sent on a scientific mission to Mexico.

MR. EINAR MIKKELSEN, a Dane, proposes to make an expedition to the Arctic regions, the objective being that part of the Polar Ocean which lies immediately to the west of the Parry Archipelago, north of Canada.

MR. S. P. JONES, formerly assistant state geologist of Georgia, has been pursuing special studies in petrography for the past six months, first at the University of Wisconsin and during the summer at Cambridge, Massachusetts, working on material loaned him by the geological department of Harvard University.

MR. LOUIS M. PRINDLE, of the U. S. Geological Survey, has returned from the Alaskan field, where during the past summer he has been making a geologic reconnaissance between the International Boundary and Fairbanks.

DR. CHAS. H. SHAW, professor of botany at the Medico-Chirurgical College of Philadelphia, has returned recently from a second expedition to the Selkirk Mountains, in British Columbia. The region of the big bend of the Columbia River, a large tract of country between the 51st and 52d degrees of N. Lat. and embracing the Selkirks has hitherto been almost unknown botanically and very imperfectly so geographically. Dr. Shaw's expedition, under the auspices of the Medico-Chirurgical College and including a number of students of botany and zoology mainly from the vicinity of Philadelphia, this year, as last, visited the big-bend region and collected some 25,000 sheets of specimens representing its flora, besides gathering data by photographs and weather readings bearing on the ecological features of this little-known mountain range.

AT a meeting of the Pharmaceutical Society of Great Britain on November 7 Sir George Watt delivered a lecture on shellac, and Mr. J. C. Umney, F.C.S., contributed a paper on the chemistry and analysis of shellac.

A SERIES of addresses on educational problems will be given under the auspices of the Department of Education of the City of New York, in Cooper Union on Wednesday evenings from November 8 to December 27. Among those who will lecture are Dr. Andrew S. Draper, New York state commissioner of education; Dr. W. H. Maxwell, superintendent of schools; Professor L. H. Bailey, director of the Cornell College of Agriculture; President Carroll D. Wright, of Clark College; Dr. L. H. Gulick, director of physical training in the city schools; Mr. Frank A. Vanderlip, the banker, and Dr. James H. Canfield, librarian of Columbia University.

UNDER the auspices of the Ethical Society of St. Louis, W J McGee, director of the St. Louis Public Museum, is giving a course of weekly lectures on anthropology to a class of twenty-five or thirty. The course presents a systematic outline of human development,

with special attention to the view that progress in culture is in accordance with definite natural laws. The class meets on Thursdays at four P.M. in the Museum of Fine Arts, Nineteenth and Locust streets; the first meeting occurred November 2. The details were arranged by Mrs. D. W. Knefler, secretary of the class.

A MONUMENT in honor of Z. Gramme, known for his discoveries in electricity, will be erected at Liège, near which city he was born.

MAJOR GENERAL SIR CHARLES WILSON, K.C.B., F.R.S., director-general of the British Ordnance Survey and of military education, known for his work on topography, died on October 25 at the age of sixty-nine years.

THE death, in his eighty-first year, is announced from Alsfeld, in Oberhessen, of Karl Müller, author of works on natural history, written conjointly with his brother.

DR. KOSTLING, vice-director of the Meteorological Bureau at Vienna, died on October 7.

THE inaugural meeting of the British Science Guild formed in April, 1904, was held on October 30, at the Mansion House. The objects of the guild are (1) to bring together as members of the guild all those throughout the empire interested in science and scientific method, in order, by joint action, to convince the people, by means of publications and meetings, of the necessity of applying the methods of science to all branches of human endeavor, and thus to further the progress and increase the welfare of the empire; (2) to bring before the government the scientific aspects of all matters affecting the national welfare; (3) to promote and extend the application of scientific principles to industrial and general purposes; (4) to promote scientific education by encouraging the support of universities and other institutions where the bounds of science are extended, or where new applications of science are devised.

A CONFERENCE of delegates from the corresponding societies affiliated with the British Association was held in the rooms of the Linnean Society, London, on October 30 and 31, under the presidency of Dr. A. Smith Woodward, F.R.S.

A CITIZEN of Denmark has given sufficient money to provide for a biological station in Greenland, and it is expected that the Danish government will defray current expenses.

BRITISH journals state that the Heriot trust governors have decided to establish a laboratory at the Heriot Watt College, Edinburgh, for the study of bacteriology in its relation to various industries. The laboratory has been fitted with the best appliances, and the services of Dr. Westergaard have been retained to supervise it. The laboratory was formally opened by a lecture by Professor Hansen, on October 18.

THE Physico-Chemical Club of Boston and Cambridge held the first meeting this autumn on November 1 in the Harvard Union. Professor Wilhelm Ostwald was present and was elected an honorary member. Professor T. W. Richards and Professor A. A. Noyes were reelected, respectively, president and vice-president, and Dr. G. S. Forbes was elected secretary and treasurer. Sixty-three members were present, who listened to a paper by Professor Noyes on the 'Hydrolysis of Ammonium Acetate and the Ionization of Water at 100°, 156° and 218°,' as well as one by Professor Richards on compressibility in relation to atomic volume and structure. Each paper was based upon entirely new data, and was followed by lively discussion.

ACCORDING to a telegram received by the Japanese consul-general in Copenhagen, the Japanese government will shortly send a special expert to Copenhagen and to the Baltic and North Sea waters in order to study the methods of carrying out international sea exploration.

THE removál of the Heidelberg University library, containing more than 700,000 volumes, into a new sandstone library building has just been completed. Each separate book was freed from dust by a cleaner operated by an electric motor, of the form used in house and carpet cleaning, the back and edges of each book being subjected to the powerful suction of the cleaner. The library requires about 21 miles of shelf room.

THE geological department of the British Museum has recently purchased and placed on exhibition a fine specimen of *Ichthyosaurus acutirostris* Owen, from the Upper Lias of Holzmaden, Wurtemberg. The specimen is remarkable as containing between its ribs the skeletons of no less than six fœtal young, as in the cases described by E. Fraas. It is supposed that these skeletons have been displaced from their natural position by crushing during the process of fossilization. On the other hand, it may be suggested that they in their struggles forced a way into the body cavity, and were thus, perhaps, the cause of their mother's death. Beddard has lately described such an instance in the recent skink, *Chalcides lineatus* (*Proc. Zool. Soc.*, London, 1904, II., p. 145); he, however, admits the possibility that extra-oviducal fœtation may be normal in some reptiles, and 'may be in part responsible for some of the legends concerning the swallowing of their young by various reptiles for protection's sake.'

THE experimental locomotive of Purdue University, Schenectady No. 2, which has recently served in an important study designed to determine the value of very high steam pressures, is to be sent to the Schenectady works of the American Locomotive Company early in November for the purpose of being fitted with a Cole superheater. It is expected that the engine will be returned with its new equipment early in January. During the absence of Schenectady No. 2 from the testing plant, a New York Central Atlantic type engine is to be installed upon the plant for use under the direction of the Master Mechanics' committee on front-ends. It is the purpose of this committee to repeat upon an engine of large size the experiments made under the patronage of the American Engineer upon Schenectady No. 2, for the purpose of determining the constants in such equations as may be necessary to the logical design of all portions of the front-end mechanism. The Master Mechanics' committee having the matter in charge consists of H. H. Vaughan, superintendent motive power, Canadian Pacific Railway, chairman; Mr. F. H. Clark, general superintendent motive power, C. B. & Q. R. R.; Mr. Robert Quayle, superintendent motive power and machinery, C. & N. W. Railway; Mr. A. W. Gibbs, general superintendent motive power, Pennsylvania Railroad; Mr. W. F. M. Goss, Purdue University; Mr. G. M. Basford, American Locomotive Company.

THE first course of lectures for the season 1905–1906 to members of the American Museum of Natural History will be given according to the following program. The lectures will be delivered on Thursday evenings at 8:15 o'clock, by members of the scientific staff of the museum and will be fully illustrated by stereopticon:

November 9, Mr. Frank M. Chapman, 'The Bird Life of Florida.'

November 16, Mr. Louis P. Gratacap, 'Newfoundland: Its Scenery and People.'

November 23, Dr. Edmund Otis Hovey, 'Northern Mexico: Its Deserts, Plateaux and Canyons.'

December 7, Professor Henry Fairfield Osborn, 'The Museum's Rocky Mountain Explorations of 1905.'

December 14, Professor Albert S. Bickmore, 'The Philippines—Manila.'

December 21, Professor Albert S. Bickmore, 'The Philippines—Luzon.'

The Army and Navy Journal calls attention to the fact that among the most valuable results of the American military occupation of the Philippines is the large and growing collection of maps of the islands prepared by officers of the army. These maps show in detail the roads, trails, rivers and mountain passes in nearly every part of the archipelago, and had they been in existence when the army began its campaign of pacification in the territory the difficulties of that undertaking would have been greatly lessened. During the domination of the Spanish little or nothing was done in that line, and they never had an accurate map, even of the larger islands. Nearly all the maps, such as they were, were prepared by the friars, whose work was performed without regard for its usefulness in military operations. But when the United States Army entered the territory it immediately instituted a comprehensive system of map making, with

special reference to military needs, and the result is a collection which, while it would be invaluable in the event of another military campaign, will also be highly useful in the peaceful development of the islands through the medium of modern roads, bridges and other improvements. These maps will probably do as much to promote the agricultural and industrial development of the Philippines as any single act of the civil government, and for them the authorities are indebted entirely to the patient, painstaking, courageous labors of the army.

The council of the Royal Meteorological Society has now appointed a lecturer who is prepared to deliver lectures on meteorological subjects, *e. g.*, How to observe the Weather; Weather Forecasting; Climate; Rainfall; Thunderstorms; Meteorology in relation to Agriculture, Health, etc. The lectures will be illustrated by lantern slides from the large collection in the possession of the society. The council is willing to arrange for exhibiting at the gatherings of local scientific societies, institutions or schools, a collection of photographs, diagrams and charts illustrating meteorological phenomena and various patterns of instruments used for meteorological observations.

UNIVERSITY AND EDUCATIONAL NEWS.

Mr. Andrew Carnegie recently offered $20,000 to Hope College, Holland, Mich., for a gymnasium, on condition that a like sum be raised by the institution. The condition has been met and the gymnasium is now being erected.

Mr. Ralph Vorhees, of Clinton, N. J., has given Huron College, a Presbyterian institution in South Dakota, a hundred thousand dollars, subject to a life annuity of five per cent.

The University of Melbourne will celebrate its jubilee in April, 1906.

Dr. Austin Scott has resigned the presidency of Rutgers College, but retains the chair of history and political science.

The following appointments have been made in the faculties of the George Washington University:

Faculty of Graduate Studies.

General Henry L. Abbott, U.S.A., retired, member of the Board of Consulting Engineers of the Panama Canal, professor of hydraulic engineering.

Edward B. Rosa, Ph.D. (Johns Hopkins), professor of physics.

Brigadier-General George M. Sternberg, U.S.A., retired, former surgeon-general of the War Department, professor of preventive medicine.

Faculty of Columbian College.

Edwin A. Hill, A.B., M.A. (Yale), Ph.D. (Columbian), assistant professor of chemistry.

Thomas M. Price, B.S. (Md. Agricultural), Ph.D. (Columbian), assistant professor of chemistry.

Timothy W. Stanton, B.S., M.S. (Colorado), Ph.D. (Columbian), assistant professor of paleontology.

Philander Betts, B.S., M.S. (Rutgers), E.E. (Columbian), assistant professor of electrical engineering.

Paul N. Peck, A.B., A.M. (George Washington), instructor in mathematics.

Department of Medicine.

Arthur M. Tasker, B.A. (Wesleyan), assistant in chemistry.

Ernest W. Brown, Ph.D. (Yale), assistant in chemistry.

Dr. Alexander McKenzie, lecturer in the University of Birmingham, has been appointed head of the chemical department at the Birkbeck College in succession to Dr. John E. Mackenzie, who has become principal of the Technical Institute, Bombay.

Appointments at King's College, London, have been made as follows: Mr. E. P. Harrison, Ph.D., and Mr. H. S. Allen, M.A., assistant lecturers in physics; Mr. C. F. Russell, B.A., assistant lecturer in mathematics; Mr. L. Hinkel, assistant demonstrator in chemistry; Mr. W. Woodland, demonstrator in zoology; Mr. O. S. Sinnatt, B.Sc., and Mr. R. Wolfenden, B.Sc., demonstrators in engineering; Mr. J. E. S. Frazer, F.R.C.S., demonstrator in anatomy.

Dr. G. N. Woldrich has retired from the chair of geology in the Bohemian University at Prague, and is succeeded by Dr. Pocta.